

Can Integrated Photonics Light the Pathway to Energy-efficient Data Centers?

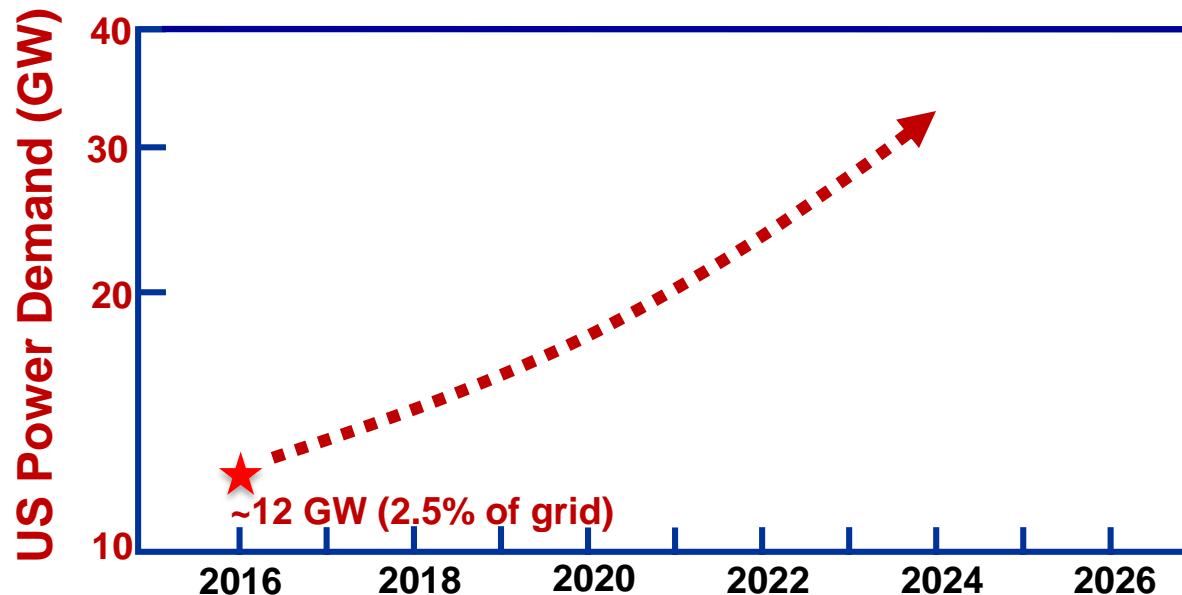
Mike Haney, Program Director, ARPA-E

February 29, 2016

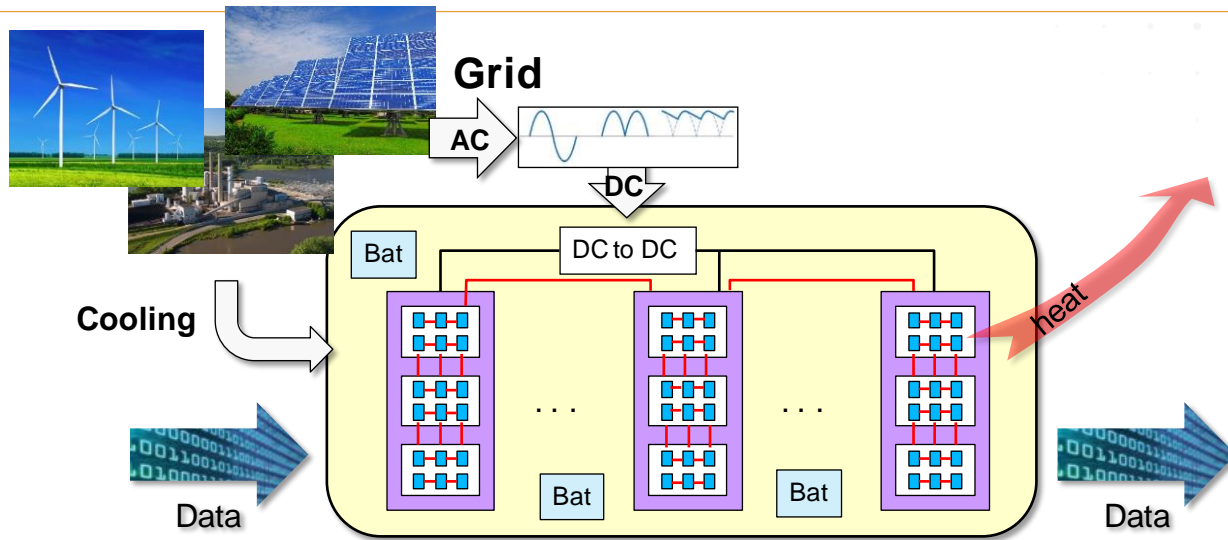


Information and Communications Technology: The fastest growing sector in energy consumption.

- Global Data Center traffic: **~100 Zetta-bits/year by 2020;**
... that's **100×10^{21} bits/year!**
... equivalent to **$\sim 200 \times 10^6$ selfies/sec.**
- Data Centers are not merely *Data Warehouses*,
.... but are Data Processing Centers.

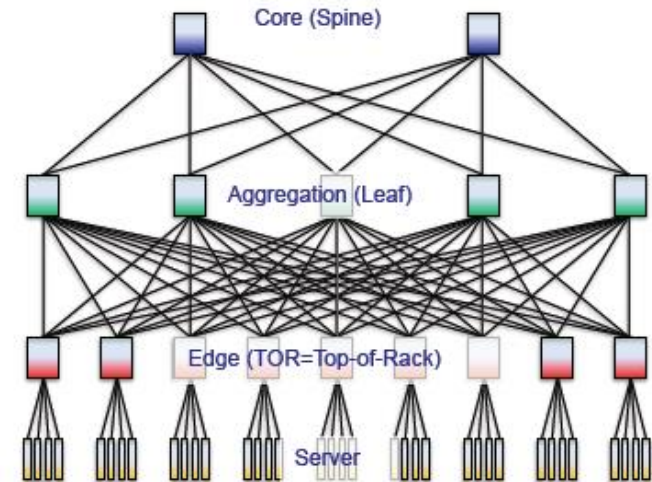


Pathways to Improving Data Center Efficiency

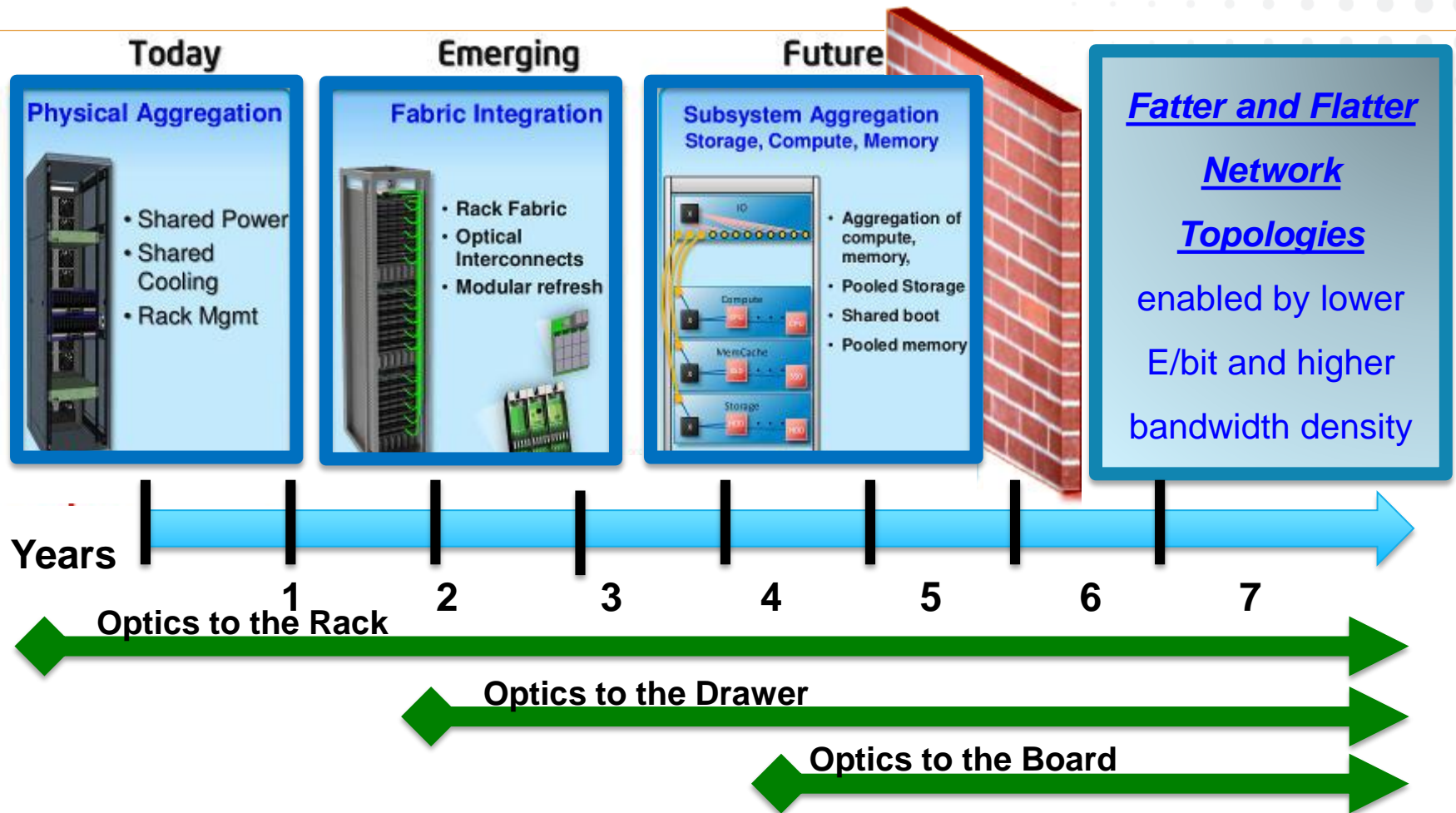


But best opportunity for transformative impact may be through **NETWORK ARCHITECTURE** advancement:

- Overcome bandwidth limits to chips that hinder performance scaling.
- Enable new network topologies to provide multiplicative performance enhancement.



Data Center Trends

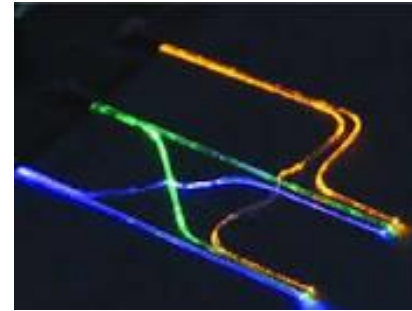


Integrated Metal vs. Integrated Photonic Interconnects



Inter-chip Integrated Electronic Interconnects:

> 1 pJ/bit
<< 100 Gbit/sec/wire



Inter-chip Integrated Photonic Interconnects:

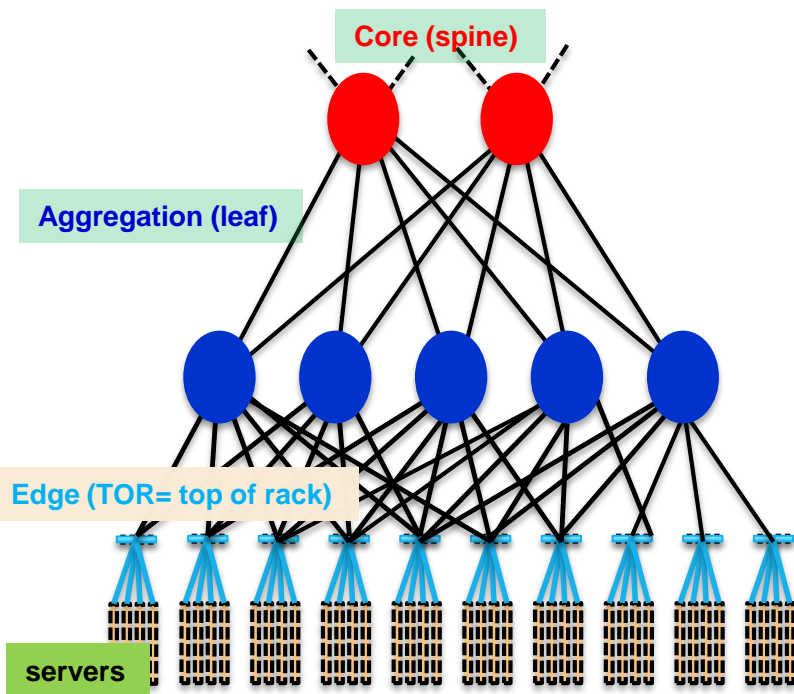
< 1 pJ/bit
>> 100 Gbit/sec/waveguide



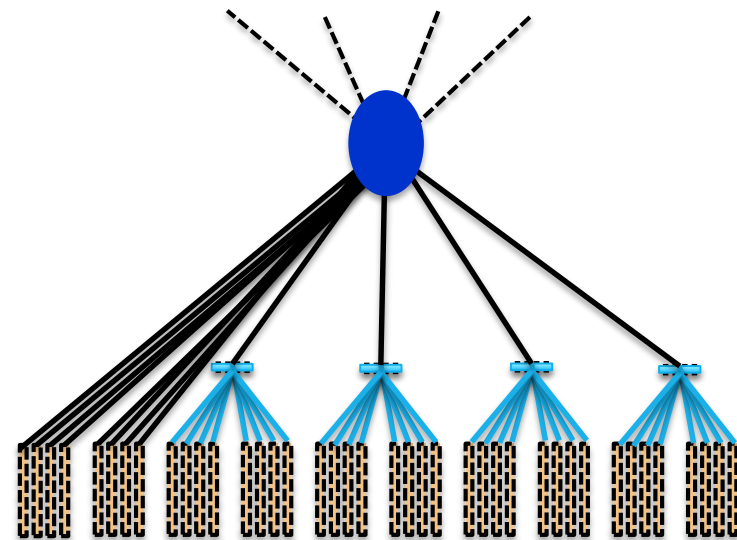
Opportunity: Overcome metal trace input/output limit in future server and switch chips → **Increase network throughput.**

Improving Data Center Throughput/Efficiency

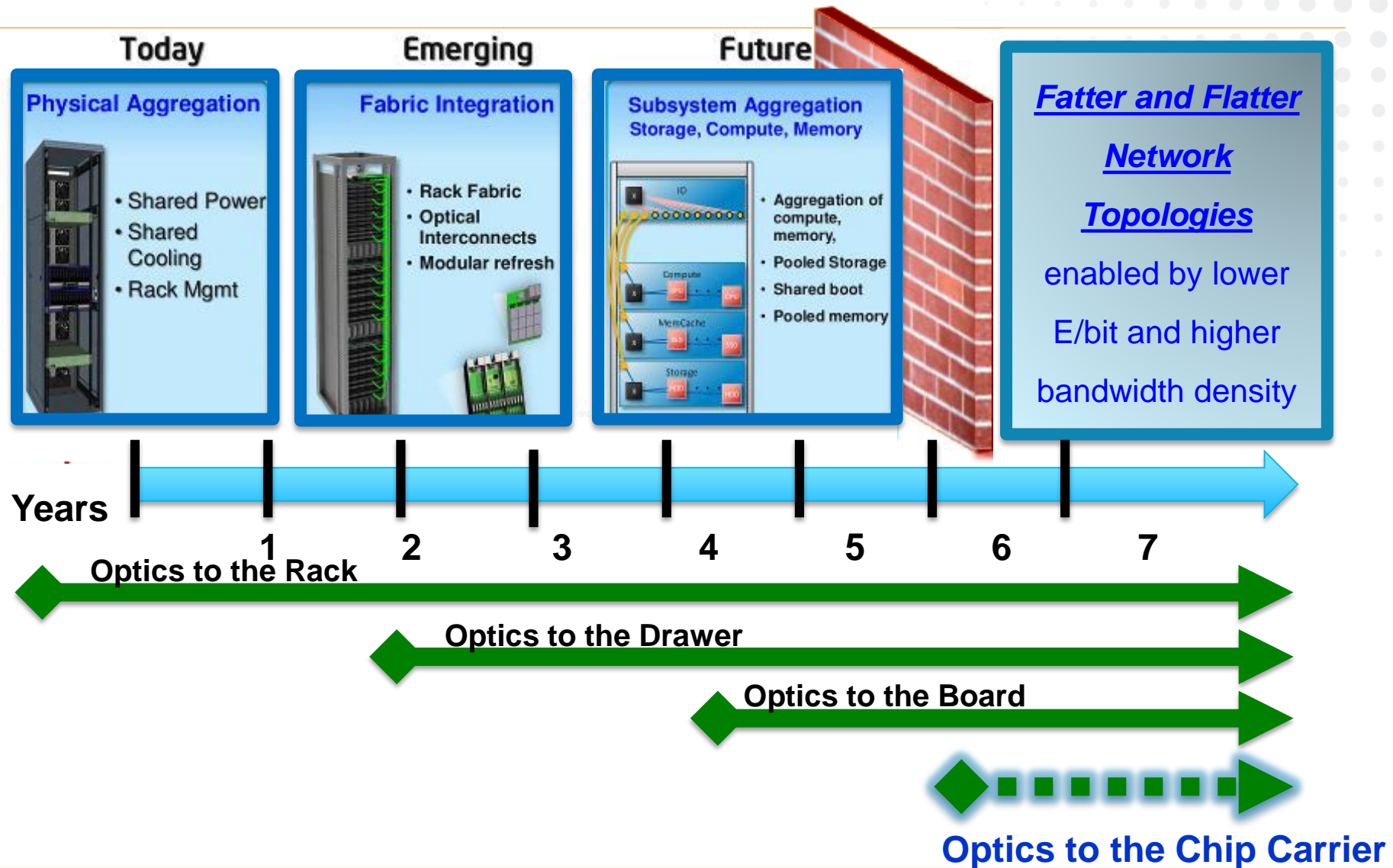
Example Data Center Topology



Example after Photonic Innovation



Data Center Trends

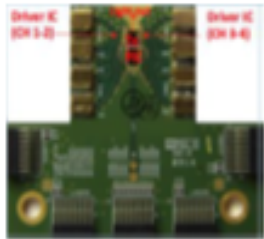


Integrated Photonic Interconnects overcome the next brick wall.

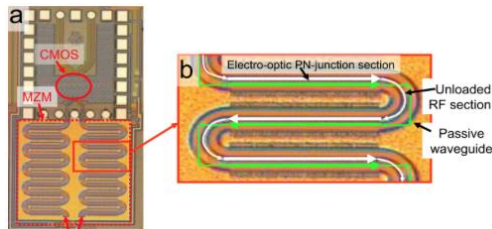
Technology Opportunity Space

Links

VCSELs, Si Photonics,
Hybrid III-V/Si, Waveguides



A. Ramaswamy et al., OFC2015



DOI: 10.1364/CLEO_SI.2014.SM2G.3,



DOI: 10.1109/ULT.2011.2177244

Switch Technologies

Ring resonators, Hybrid
Electro-Optical, AWGs...

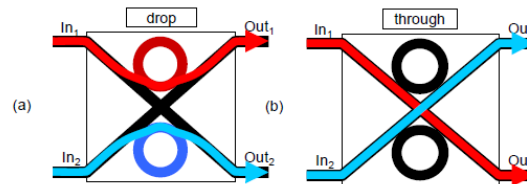
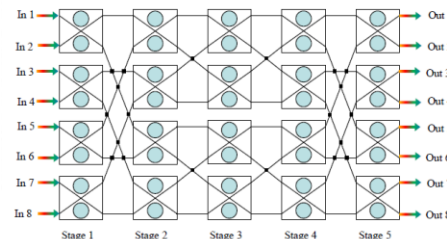
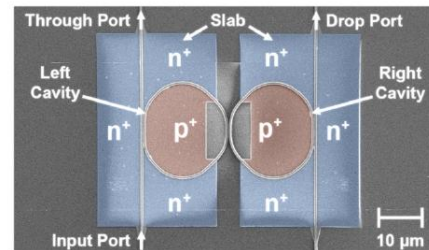


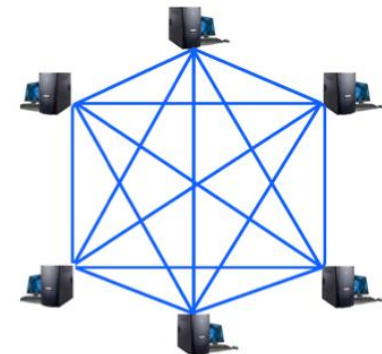
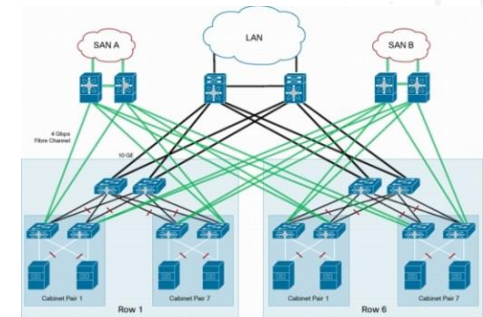
Fig. 1. 2×2 Switching element in (a) "drop" and (b) "through" state.



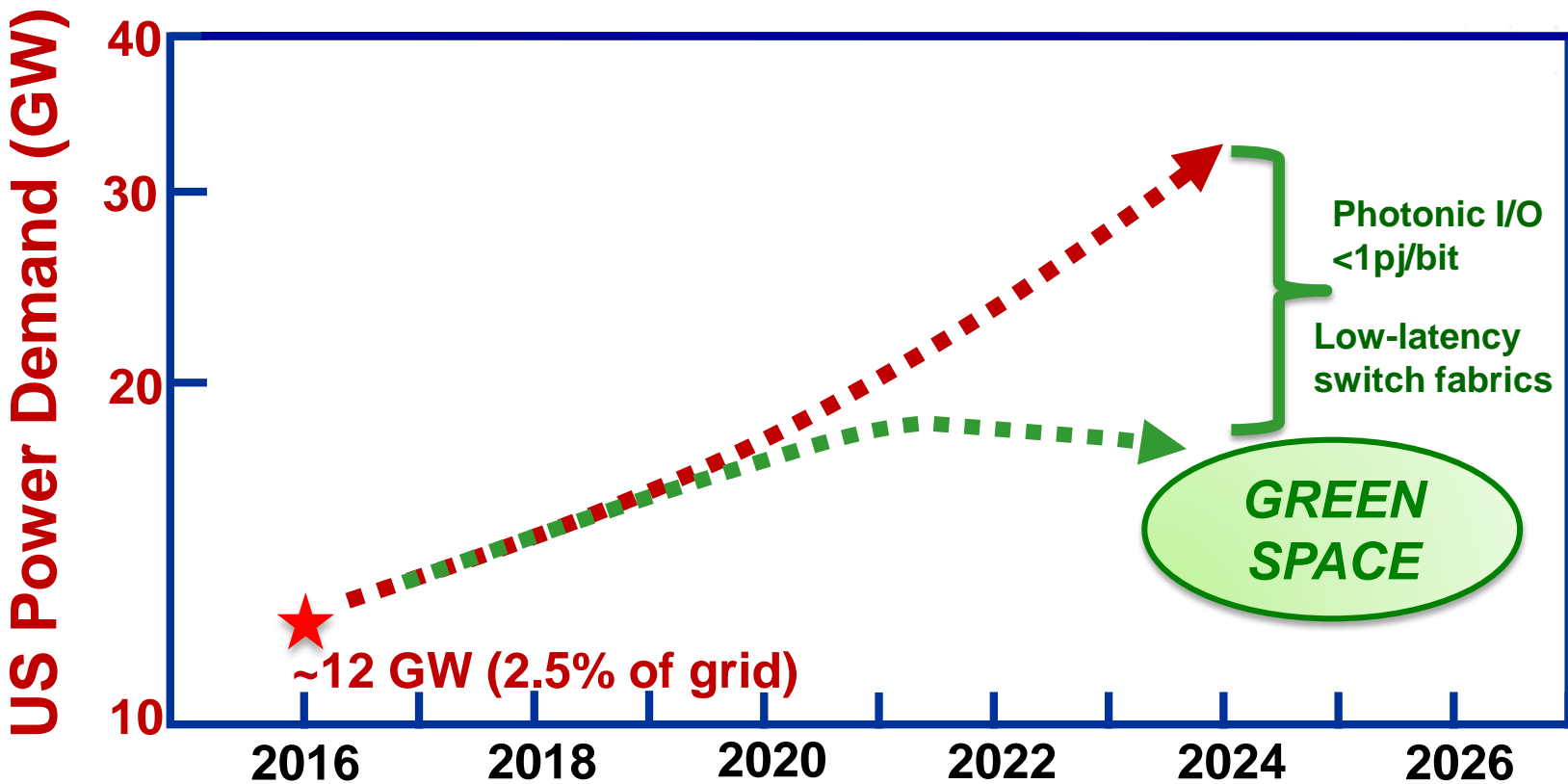
DOI: 10.1364/OE.23.0001159,
Rep. Prog. Phys. 75 (2012) 045402

Network Architecture

Fat Tree, Flattened Butterfly
All-to-All, Algorithms



Data Center Challenge and Opportunity Projections



“Teaming Partner List” Just Published:

Energy-efficient Light-wave Integrated Technology Enabling Networks that Enhance Datacenters
“ENLITENED”



CHANGING WHAT'S POSSIBLE

Thank You!